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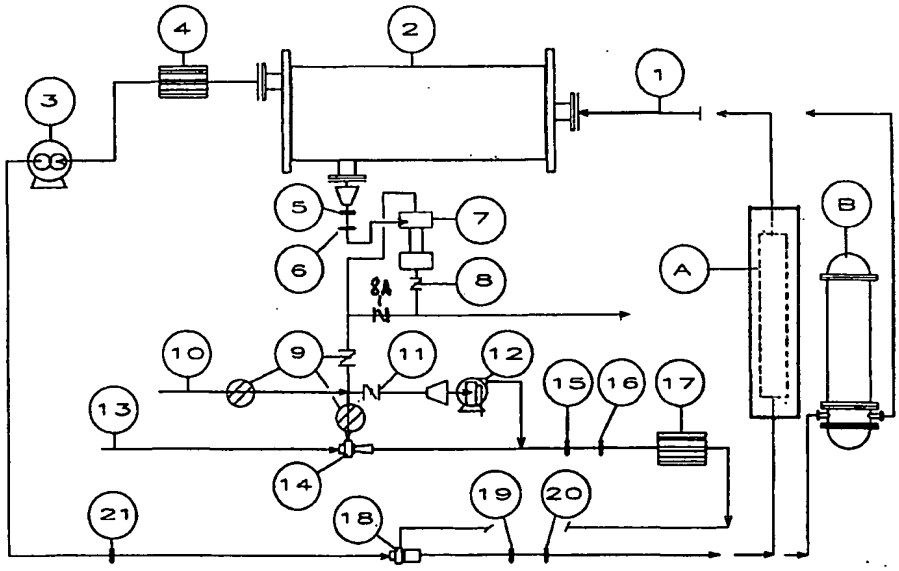
(57) Abstract

The invention relates to a method for generating a scale–removing or coat–applying system based on a vacuum–balancing low–pressure multi–component two–phase fluid flow. A cleaning site such as, e.g., a pipe circuit (A) or the inner cavities of a heat exchanger (B) is supplied with an already used cleaning agent in a two– or multiphase flow made up of ca. 10 % liquid and ca. 90 % air or gas, which after separation is used again by way of continuously monitoring the ion density of the separated liquid, using a conductivity apparatus which determines whether it shall be filtered and reused, be supplied with new liquid and/or solids, or be dumped. A liquid flow and separated air/gas flow from an air pump meet at a mixing point from where an intended two–phase flow flows to the cleaning site (A), (B), or similar, through this and then forward to return as a re–use medium. A gas–injected liquid/powder flow from a mixing unit is also used for coating, e.g., the inner surfaces of pipes and tanks, or objects placed in a suitable chamber, tunnel, or similar, where excess coating medium is returned for separation for possible re–use, re–introduction or dumping. The method operates an expansion separator (2), air pump (3), conductivity meter (5), cyclone filter (7), valve control (11), pump (12), vapour supply (13), ejector (14), mixing head (18) and sundry pressure (15), temperature (4, 6, 17, 20) and volume (16, 21) control units.



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METHOD AND APPARATUS FOR TREATMENT OF INTERNAL SURFACES IN A CLOSED-LOOP FLUID SYSTEM.

The invention relates to a method for generating a scale-removing and coat-applying closed system based on a vacuum-balancing low-pressure multi-component two-phase fluid flow.

Methods used in the industry include vast amounts of chemicals and solvents for the various applications. In spite of a generally increasing level of technological improvements and increasingly stricter standards for process cleanliness, large amounts of dangerous and toxic substances pollute the air and water, substances that slowly or never decompose, and which may form new compounds that are harmful to animals and humans.

One of the main problems today concerning the use of dangerous chemicals and solvents is the industry's need for fast solutions at low cost for various types of scale removal. Thorough assessments are made primarily of such fast-acting and cheap solutions.

The result can often have an opposite and negative impact on the environment. The list below shows a few areas where chemicals and solvents are used, and where various methods are currently utilised for removing scale.

- Algae growth and other organic sediments, e.g., on the inside of pipes transporting water through a pipe network for consumption, fire-fighting facilities and other industrial needs. Said pipe networks can have major dimensions, for example in water mains from reservoirs to cities, and smaller dimensions such as in buildings and ships, etc.
- Deposits in pipelines of carbonates, phosphates, etc., which over time are precipitated from the liquid flow.
- Deposits in pipes, such as in oil, paraffin and fatty gradations.
- Corrosion deposits arising with oxidation over time, e.g. in pipe systems and internal surfaces of tanks.

Today's heavy-duty scale removal is to a great extent done by jet water washing and the use of a host of chemical solvents, also combined with high liquid temperatures.

Current knowledge about, and use of, chemicals and solvents is to some extent advanced high technology. On the other hand, when it comes to the actual physical performance of tasks using such agents, the methods and procedures are relatively less advanced, with major waste, danger of discharging these agents into the environment and of injury to personnel. Because time reduction and cost savings have become the key factors for achieving the set goals, inadequate control of the properties of chemicals being present in a process activity have had to be accepted. For example, unstable temperatures may cause toxic vapours and fast-corroding reactions. The concentrations of the cleaning fluid must be controlled at all times in order to achieve the intended effects and to avoid wasting chemicals. It must be possible to carry out quality control, both during the process and after completion. This relates to human errors, time excesses, rejects, etc.

Applying high-pressure effects for cleaning the inner walls of pipes calls for a high velocity of fluid flow/liquid flow filling the internal volume of the pipe. The same effect is achieved with lower pressure with a standard two-phase flow in pipes by injecting air or another gas into the liquid flow, which increases the liquid velocity along the pipe walls.

The following is cited from patent literature:

- EP O 490 117 A1 describes a procedure for cleaning a pipeline with the aid of a two-phased flow based on liquid and gas, achieving an internal helical annular-flowing travel through the pipe, attuned according to the density, surface tension, viscosity and given velocity of the fluid. The procedure allows a gas/liquid mix ratio in the order of 3,000 to 7,500 m^3 : 1 m^3 or in the order of 2.0 to 6.0 kg : 1 kg.

The apparatus for carrying out the procedure is based on a *source of pressurized gas* for blowing the gas flow through a supply line supplied with liquid from a separate source at an angle of 45° to the pipeline axis.

The method according to my invention is based on a *vacuum-balancing low-pressure two-phase fluid flow*, which reduces the danger of waste or leakage into the environment,

and which allows the recovery of both liquid and gas.

- US 5,169,454, 5,538,025 and 5,051,135 describes devices for cleaning objects in a closed chamber with permanently installed nozzles that spray liquid over the objects.
- US 4,977,912 describes a carwash machine in which particles are mixed in the liquid to remove film on car surfaces. The particles are recovered from the liquid through centrifugal separation before the used liquid is dumped.
- US 5,298,082 describes a degreasing unit where the degreasing agent is cleaned for re-use. New liquid is constantly added to the degreasing agent to maintain its effect.
- US 4,784,169 involves a system whereby liquid is sprayed onto objects and then cleaned through a filter system for impurities. The cleaned liquid can be used again.
- US 4,770,197 involves a system whereby you can use dangerous solvents to wash objects in a closed chamber. After use, the gas is condensed/liquefied in the chamber and cleaned before it is discharged into the atmosphere. The liquid is collected at the bottom of the closed chamber where it is reprocessed.
- US 3,378,018 involves a unit that cleans the used liquid from a carwash machine so it can be used again.
- US 3,687,729 describes a system for manually cleaning plane surfaces. A cap encloses the nozzle for sucking up and recovering the used liquid to avoid spills. The liquid is dumped into a container.

According to the present invention, the scale removal from, and application of coating to, the insides of cavities or objects placed in closed chambers is based on using a vacuum-balancing, low-pressure, multi-component, two-phase fluid flow consisting of a small amount of liquid, which, when added chemicals mixed with large amounts of air or other gas, is allowed to circulate out from a device for the purpose, through a restricted part of a pipe network or through a closed chamber or similar, after which it is returned to a unit of equipment for liquid-gas-solids-separation in an expansion/vacuum chamber. With known methods of continuous measurement of conductivity of the

liquid flow, an ion-density indicator will indicate whether to filtrate impurities from the cleaning fluid so that the fluid can be re-used, or whether the fluid has been used so much for its purpose that it should be replaced.

The invention is a vacuum-balancing, velocity-regulated, low-pressure-operated system produced with standard two-phase methods, whereby gas such as, e.g., air comprises most of the fluid flow volume.

"Standard two-phase methods" refers to fluid mechanics, which involves the flow of gas and liquid in pipes. In this case, liquid, gas and solids are referred to as phases. Fluid mechanics describes which flow regime you get with different velocities of liquid and gas, and the relationship between those two elements.

The method involved in this patent claim aims, through cleaning and coating, to establish a flow regime that generates an annular flow with gas in the centre, surrounded by liquid along the inside walls of the pipe and an aerosol fog flow with the liquid dissolved in droplets in the gas flow. With an annular flow, the liquid/gas ratio is 1:10 and with an aerosol fog flow it is 1:100. Because of the velocity of the liquid and gas, Reynolds number would be high, achieving turbulent flow, which is optimal for cleaning surfaces because its velocity profile corresponds to uniform velocity throughout the pipe, as opposed to laminar flow, where the highest velocity is in the centre of the pipe and low velocity at the pipe walls.

The invention eliminates high exposure to toxic/acidic vapours because of its automatic monitoring and maintenance of stable temperatures in its closed system for circulating and recycling cleaning fluids.

Liquid consumption is thereby significantly reduced, and because the system is vacuum-based, there is minimal risk of leakage into the atmosphere, only leakage of air into the system.

Fig. 1 shows the flow chart of the process with a circulation pattern where the utilised cleaning agent, e.g., liquid-air 1 after completed cleaning through a pipe circuit A or, e.g., a heat exchanger B, is returned to a gas-and-liquid/solids expansion separator 2 with a large cross

section, which entails that the air looses its velocity and thus its ability to transport the cleaning agent, which because of its high weight will sink to the bottom of the separator for drainage, while the air escapes through the top of the separator.

From this separator, the separated gas part flows to the air pump 3, which with air-temperature control 4 via a flow meter 21 is returned to the mixing head 18. After the air has been separated in the expansion separator, it flows through the air accelerator which, in order to ensure the optimum operating temperature of the process with a control unit, also adjusts the temperature of the air up or down. Control of the velocity of the gas phase and the liquid phase is achieved with a flow meter 21 in order to adjust the flow of the phases to the desired flow regime.

From expansion separator 2, also the separated liquid/solids part flows to a conductivity meter 5, which, with its ion-density-indicating monitoring, determines whether the liquid's consistency is suitable for continued use. After passing the temperature meter 6, the liquid, if usable, passes a cyclone filter or similar 7 for separation of impurities for dumping via a valve 8A. If the conductivity meter 5 determines that new liquid must be added, the used liquid will go to dumping without separation.

Valves 9 controlled by the conductivity meter 5 determine the intake of cleaned, used liquid or of new liquid and/or dry substances from a supply line 10, possibly with the supply of vapour 13 to an ejector 14.

With valve control 11, the now selected liquid flow can either pass via a pump 12 or ejector 14 with a pressure meter 15 for safety purposes and a meter for measuring the quantity of liquid 18 to the fluid-temperature-adjusting control unit 17 before the liquid flow meets the air flow from the air pump 3 in the mixing head 18.

From this mixing head 18, new flowing amounts of gas and cleaning fluid are generated out to the coating or cleaning site via the pressure meter 19 and temperature gauge 20 before they are again returned as a re-usable agent 1 to the expansion separator 2.

Fig. 2A shows the curve for a *laminar* flow regime.
Fig. 2B shows the curve for a *turbulent* flow regime.

C l a i m s

1. Method for treatment in the form of scale removal from, or application of coating to, internal surfaces in a closed fluid system (A,B), such as pipes and tanks, by the use of a two- or multi-phase fluid flow being brought through the fluid system,
c h a r a c t e r i z e d i n that the fluid flow is composed (18) of liquid and gas with a substantially higher volume of gas than of liquid, being that liquid and gas in a quantity-controlled (16,21) ratio and with a given pressure are supplied to a mixing head (18), the outlet of which is connected to an inlet to the fluid system (A,B), while an outlet from the fluid system leads to an expansion separator (2),
that liquid and gas exit separately from the expansion separator (2),
that the gas from the expansion separator (2) is brought with the aid of a pump (3) to the mixing head (18),
that the liquid, possibly containing solid substances or particles from the expansion separator, is filtered (7) to separate unwanted components from the liquid, and that at least a part of the liquid is recycled to the mixing head (18), preferably with the aid of a pump (12).

2. Method according to claim 1,
c h a r a c t e r i z e d i n that the gas volume is in the order of magnitude of about 10 times that of the liquid volume.

3. Method according to claim 1,
c h a r a c t e r i z e d i n that the liquid is brought to aerosol fog form after the mixing head (18) and that the gas volume is in the order of magnitude of about 100 times that of the liquid volume.

4. Method according to claim 1, 2 or 3,
c h a r a c t e r i z e d i n that the liquid from the expansion separator (2) is subject to a measurement (5) with regard to liquid components resulting from or affected by said treatment, and
that the measurement (5) is adapted to to control a valve arrangement (9,11,8A) which directs the liquid for recycled supply to the mixing head (18) or to dumping of non-reusable liquid or possibly solids or particles, and which provides for the supply (10) of new liquid according to requirements.

5. Method according to claim 4,
c h a r a c t e r i z e d i n that the measurement (5) comprises electrical-conductivity measurement.

6. Method according to claims 1-5,
c h a r a c t e r i z e d i n that the liquid is filtered in a cyclone (7).

7. Method according to Claims 1-6,
c h a r a c t e r i z e d i n that the supply of new liquid (10) is accompanied by the supply of solids.

8. Method according to claims 1-7.
c h a r a c t e r i z e d i n that the supply of new liquid is provided in whole or in part in the form of vapour (13).

9. Method according to claims 1-8.
c h a r a c t e r i z e d i n that temperature and pressure are measured at different points (4,6,15,17,19,20) in the fluid flow with the aim of monitoring and controlling the treatment.

10. Method according to one of the preceding claims, designed for coating,
c h a r a c t e r i z e d i n that a coating agent is supplied in the fluid flow before the inlet to the fluid system (A,B), and
that excess coating agent is returned from the expansion separator (2) for recycling or dumping (8).

11. Method according to one of the preceding claims, c h a r a c t e r i z e d i n that the pressure in the fluid flow (liquid and gas) is everywhere kept lower than the ambient pressure.

12. Apparatus for treatment in the form of scale removal or application of coating to internal surfaces in a closed fluid system (A,B), such as pipes and tanks, by the use of a two- or multiphase fluid flow being brought through the fluid system,
c h a r a c t e r i z e d i n that a mixing head (18) with quantity-controlled (16,21) inlets for gas and liquid, respectively, and an outlet which is adapted to be connected to an inlet to the fluid system (A,B),
an expansion separator (2) with the inlet which is adapted to be connected to an outlet from the fluid system,
separate outlets for gas and liquid, respectively, with possible content of solids or particles from the expansion separator (2), a pump (3) for transferring the gas from the expansion separator to the gas inlet on the mixing head (18),
a filter unit (7) connected with the liquid outlet from the expansion separator (2),
a valve arrangement (9, 11, 8A) connected with the liquid outlet from the expansion separator (2) with mixing head (18),
the filter unit (7), and an outlet for dumping non-reusable liquid or possibly solids or particles, and a supply line (10) for new liquid, in that recycling of liquid to the mixing head (18) is done preferably with the aid of a pump (12).

13. Apparatus according to claim 12, c h a r a c t e r i z e d i n that it includes control arrangements (4,6,15,17,19,20) for temperature and pressure at various points (4,6,15,17,19,20) in the fluid flow with the aim of monitoring and controlling the treatment.

14. Apparatus according to claim 12 or 13, c h a r a c t e r i z e d i n that a measuring unit (5) is connected with the liquid outlet from the expansion separator (2) for determining parameters regarding components in the liquid, and that the valve arrangement (9,11,8A) is controlled by the measuring unit (5).

FIG. 1

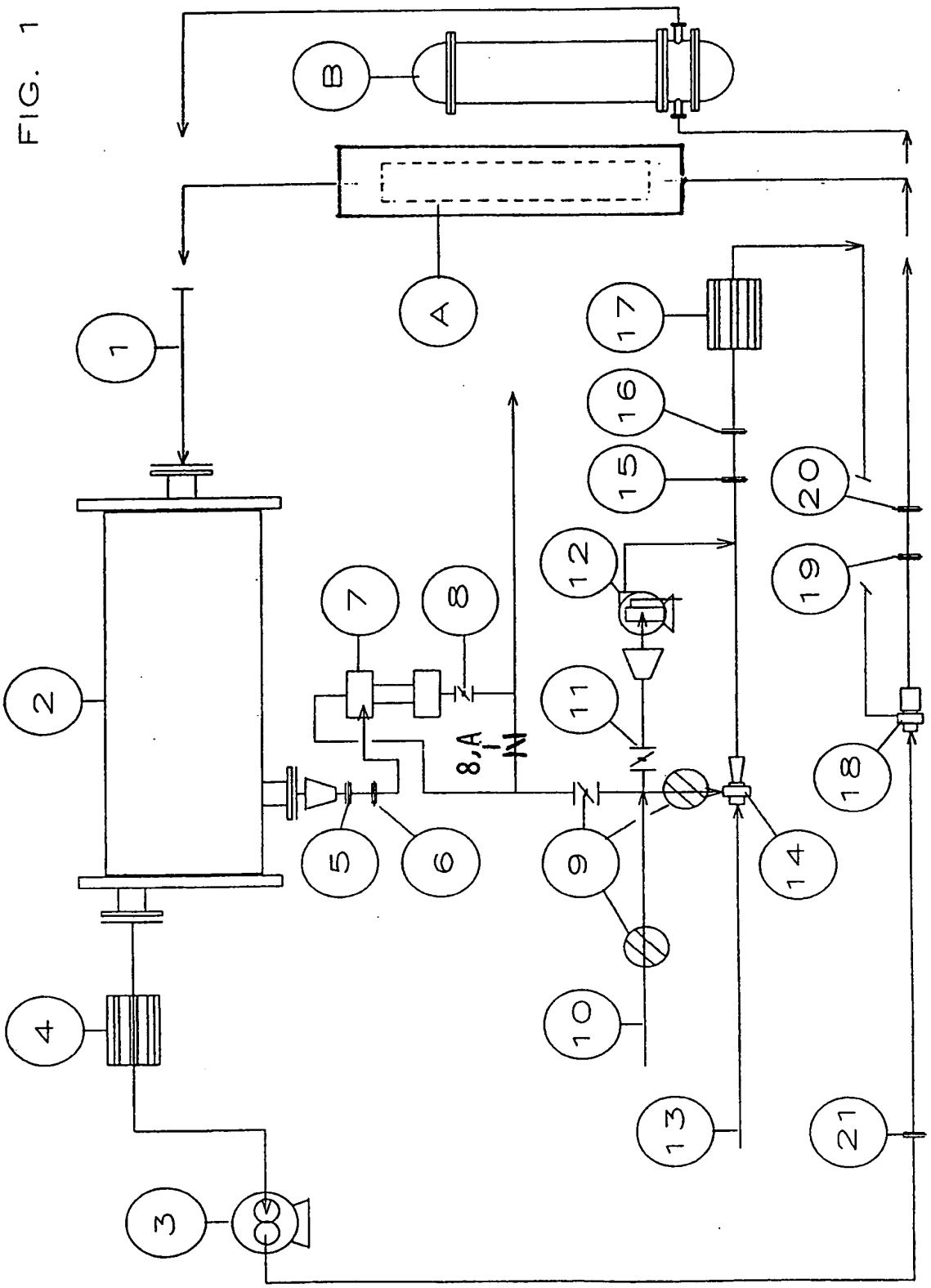
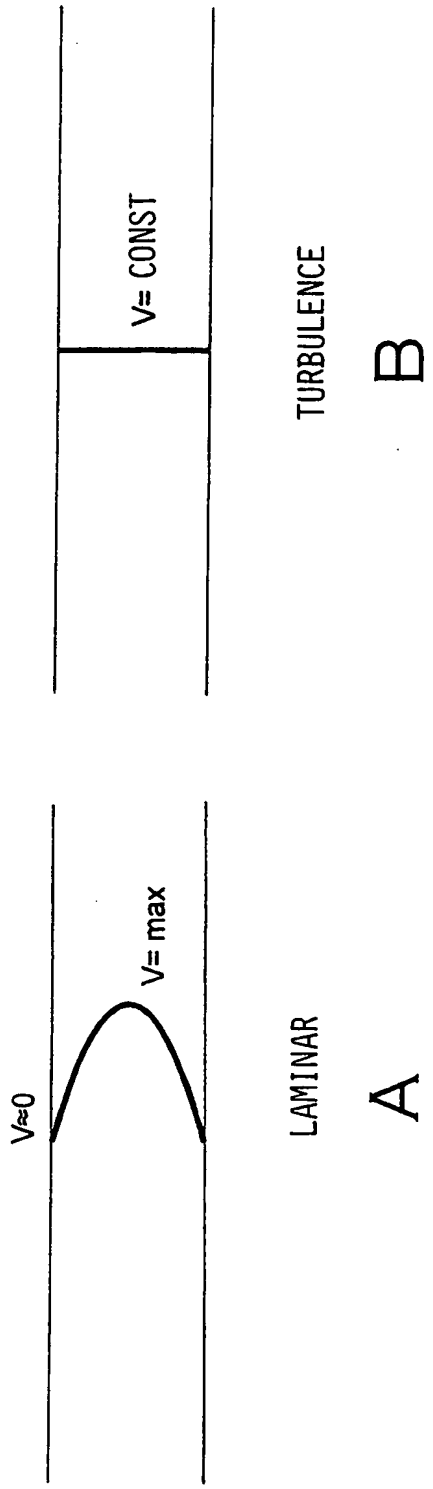


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00219

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B08B 9/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B08B, B05C, B05D

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9841337 A1 (BENTLEY, M.), 24 Sept 1998 (24.09.98) --	
A	EP 0634229 A1 (PROMOTEC AG), 18 January 1995 (18.01.95) --	
A,D	EP 0490117 A1 (BüHLER AG), 17 June 1992 (17.06.92) --	
A	DE 4013698 A1 (BENTELER AG), 7 November 1991 (07.11.91) --	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Information on patent family members

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DE 4013698 A1	07/11/91	NONE	